

eRHIC studies

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Motivation

- Proton/ion beam parameters in eRHIC differ from presently achieved beam parameters.
- Smaller transverse and longitudinal emittances by cooling (CEC):
 - Relatively large space charge (0.035)
 - Small bunch length (5-10 cm) and much larger peak current
- Two studies to test the feasibility of eRHIC proton beam parameters:
 1. Study of bunch length limits
 2. Interplay of space-charge and beam-beam effects

Study of bunch length limits

V.Ptitsyn, V.N.Litvinenko, A. Marusic, M. Minty,
C.Montag, S. Tepikian, S.Y.Zhang

Goals:

- To identify and observe effects which may put limits on the minimum bunch length in RHIC.
- To distinguish the limitation coming from resistive wall heating and electron cloud (vacuum, pipe heating) and identify the heat load on the beam pipe from both effects.

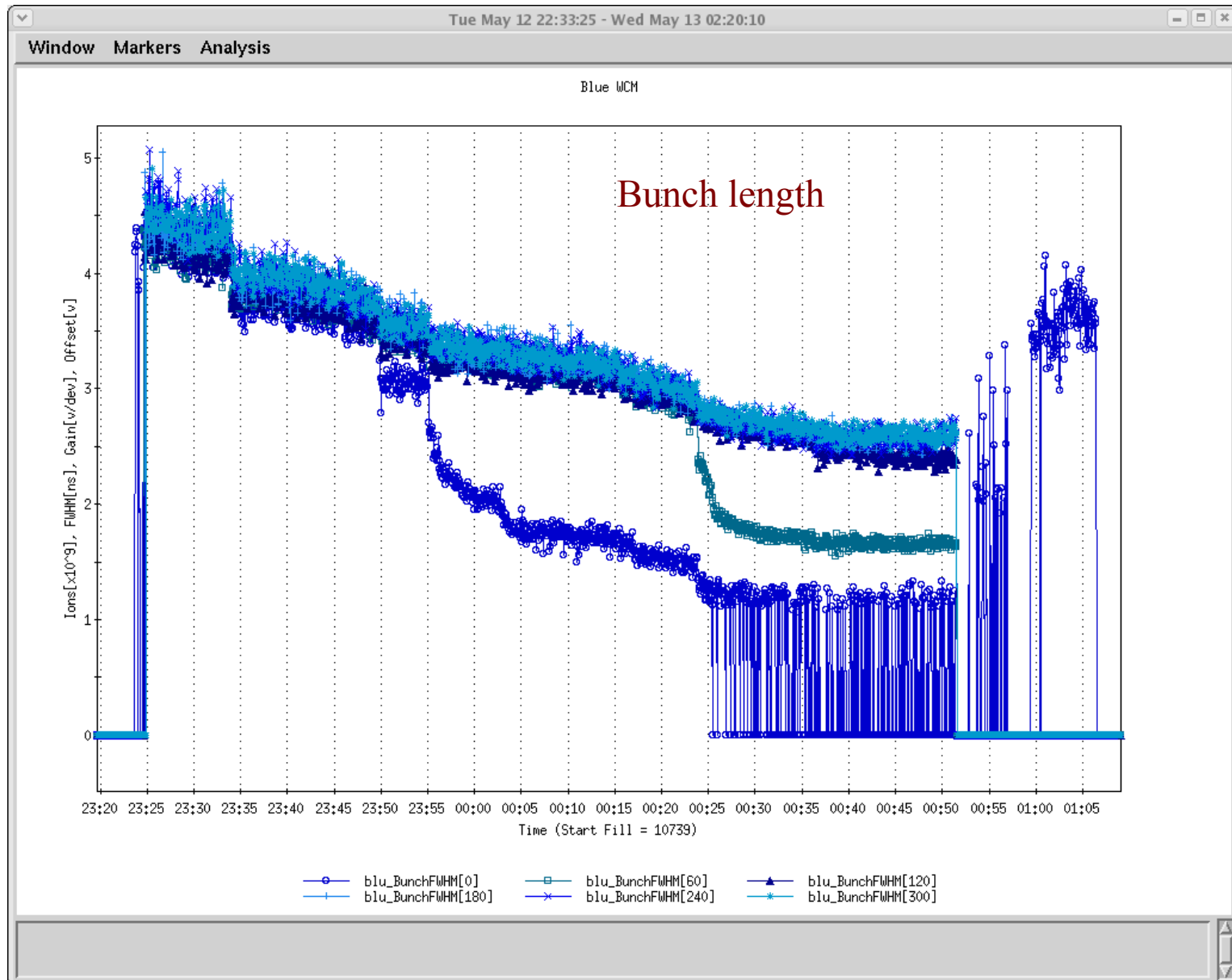
The effects of interest

- Beam pipe heating: resistive and electron cloud
- Instabilities: longitudinal microwave; transverse EC related
- BPM cable heating

Approaching transition study in Run-9

- ~2h time spent to verify if we could approach the transition at fixed energy, using gammaT quads only:
 - Beam losses when large step of gammaT quad change was used
 - Some model problems when trying to calculate the required tune correction.
 - Considerable closed orbit change.
 - Conclusion: a dedicated ramp and tune/orbit feedbacks are needed to prevent beam losses during the experiment.

Approaching transition using gammaT quads. Run-9.



High intensity studies in Run-12

C. Montag and team

- achieved peak current = 7.5A (2.6×10^{11} with 2.2ns rms bunch length) by injecting into 28 MHz RF with the quad-pumping in AGS.

(Peak current in eRHIC > 75 A)

- with 109 bunches injected, the measured cryo-load was consistent with expected resistive wall heating (to 10% level)
- not obviously seen: the electron cloud and related transverse emittance growth

Plans for 2013

- Inject the proton bunches with intensities about $2\text{-}2.5 \times 10^{11}$.
Use 28 MHz RF system with highest possible voltage and, possibly, quad pumping technique in AGS. (197 MHz RF?)
- Use a slow ramp with tune and orbit feedbacks:
 - Take advantage of the new Yellow beam lattice with higher gammaT energy.
 - Initial part of the ramp: ramping the gammaT quad settings, with corresponding tune corrections.
 - Second part of the ramp: slow (~few minutes) deceleration to the transition energy
- Record cryo-temperatures, vacuum conditions, transverse and longitudinal beam sizes (emittances).
- Possible complications: increased space charge effect; BPM cable heating
- Make ramps:
 - with small number of bunches of different intensity to look at the instabilities and the space charge effects
 - with 109 bunches: to look at the pipe heating and EC effects

Interplay of space-charge and beam-beam effects

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APEX studies for **low-energy RHIC** (with Au ions)

$$\Delta Q_{sc} \gg \xi$$

- **APEX March 2010:**

Au+Au ions: $\gamma=10$ (**modest space-charge, small beam-beam**)

- **Several APEX and Low-Energy RHIC run May - June 2010:**

Au+Au ions: $\gamma=6.1$ and $\gamma=4.1$ (**large space-charge, small beam-beam**)

- **June 2011:**

Au+Au ions: $\gamma=10$, w.p. near integer (**modest space-charge, small beam-beam**)

Results published in:
Proc. of HB10: THO1C03;
Proc. of PAC11: THP081

Team: A. Fedotov, M. Blaskiewicz, R. Connolly, A. Drees, W. Fischer, C. Montag, V. Ptitsyn, S. Tepikian

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Experimental studies in RHIC with protons:

- Mostly relevant **for eRHIC** parameters & luminosity

large beam-beam parameter ξ

1. May 2009:

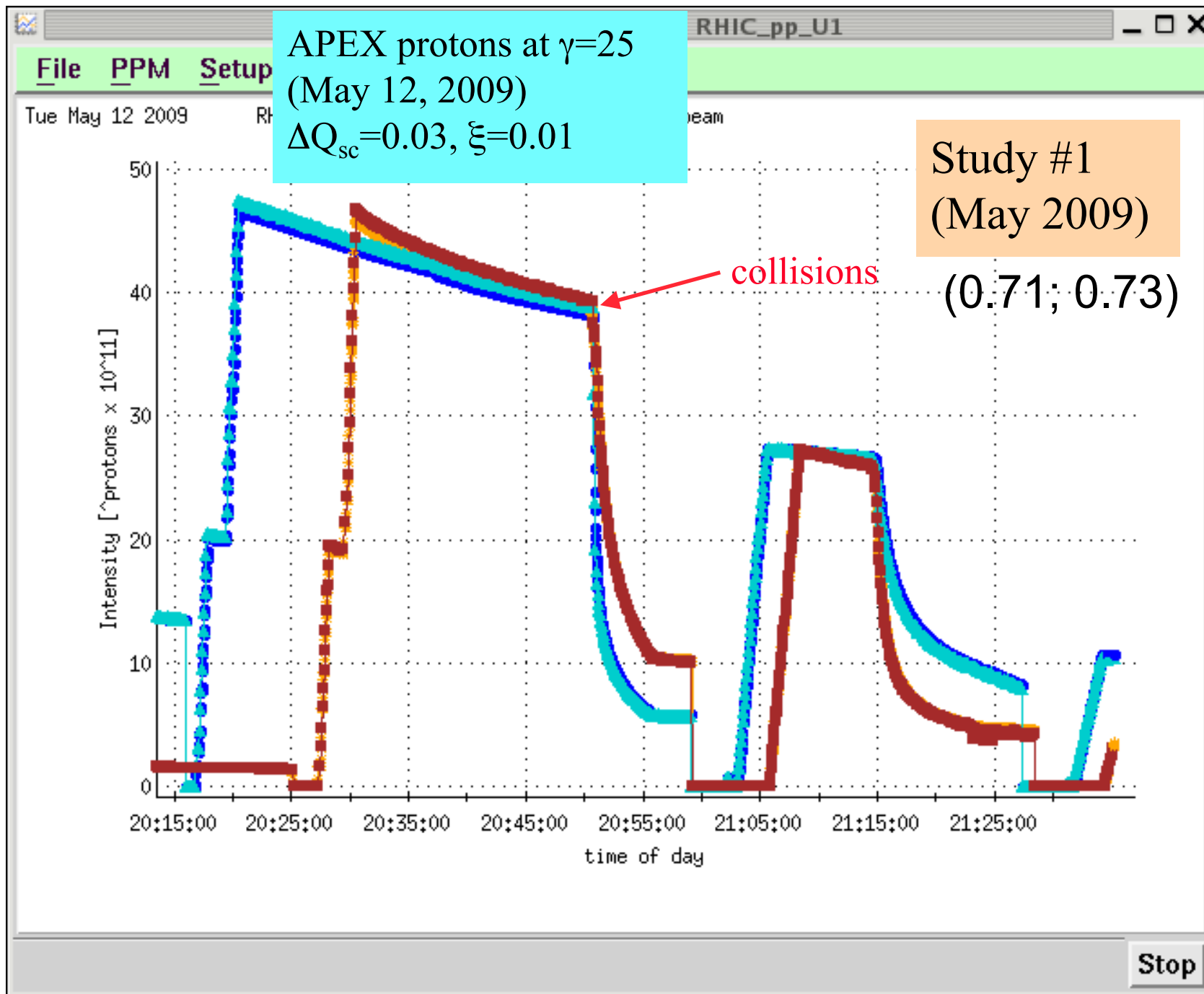
Protons at $\gamma=25$ (**large beam-beam**)

2. June 2009:

Protons at $\gamma=25$ and different w.p. (**large beam-beam**)

3. April 2012:

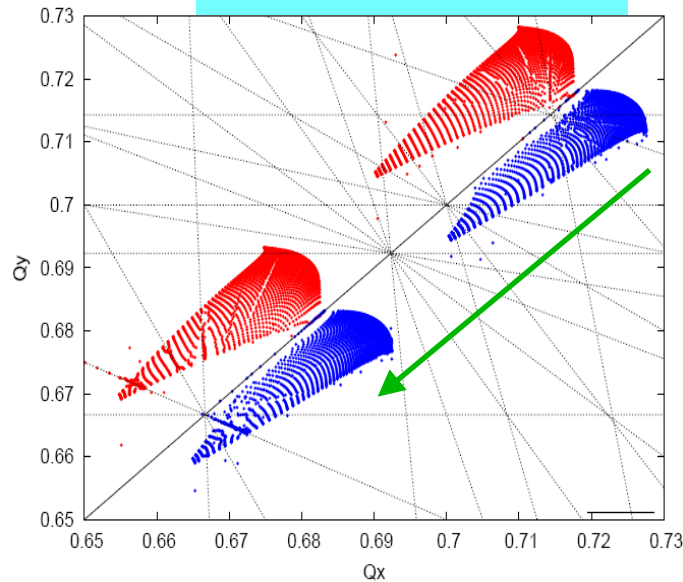
Protons at $\gamma=25$ and near integer w.p. (**large beam-beam**)



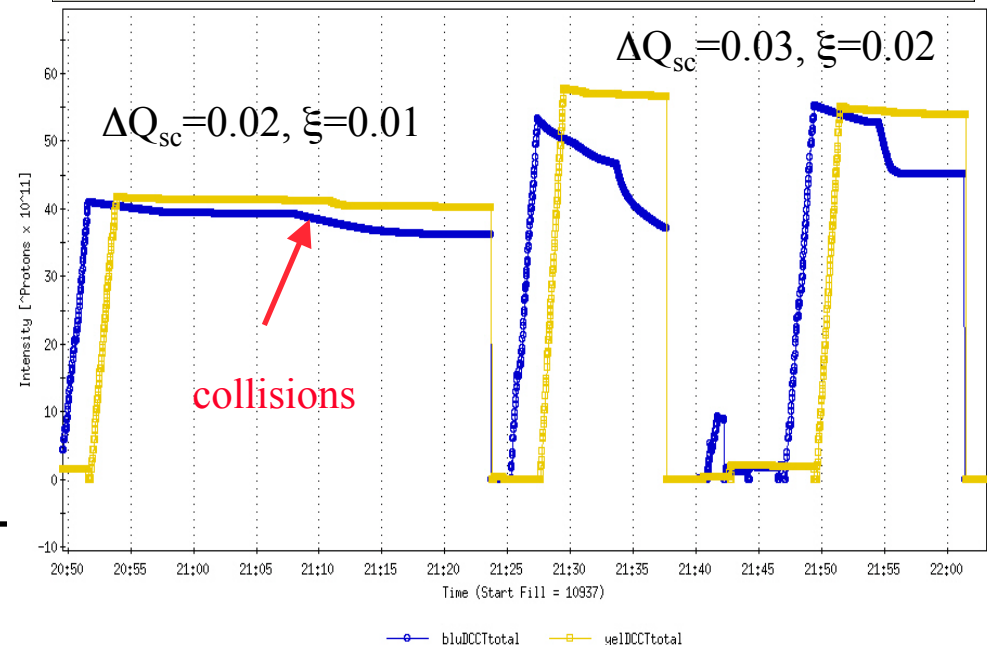
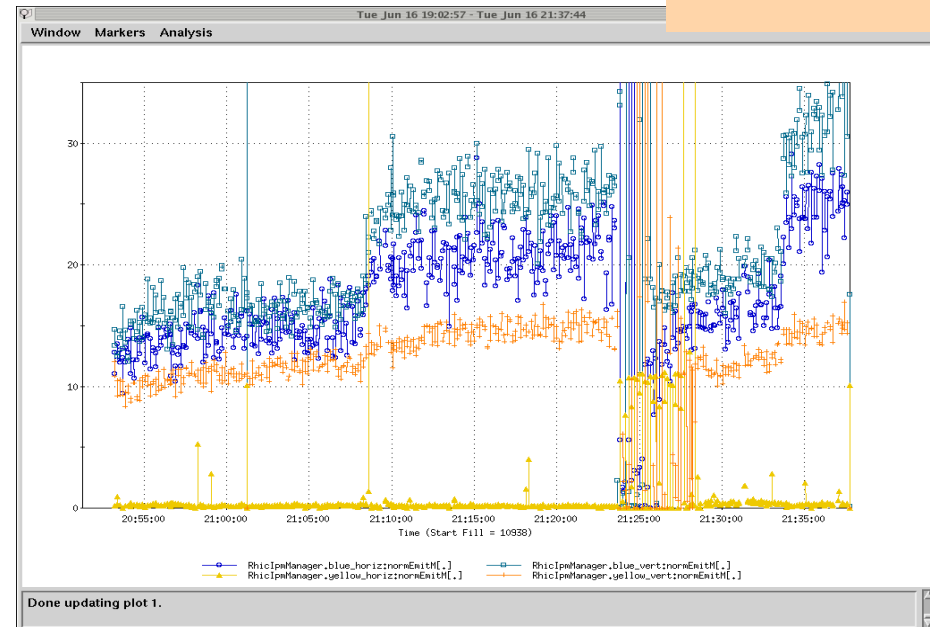
June 17, 2009 experiment with new working point

study # 2
June 2009

APEX with protons
(June 17, 2009)



Choosing different working point for regime with large beam-beam.



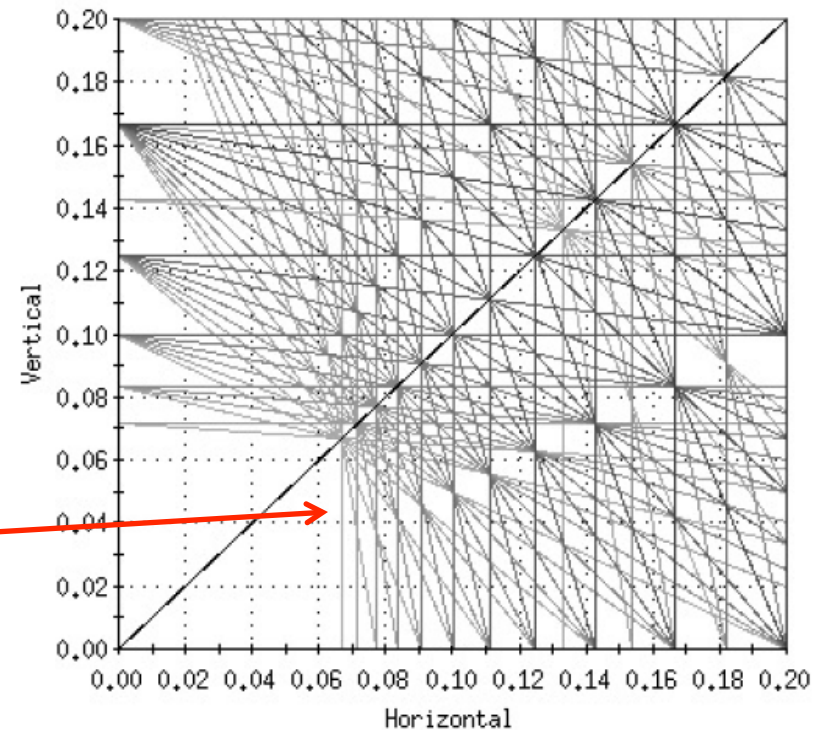
Protons at standard injection energy ($\gamma=25$):

Finding working point where effects of beam-beam are minimized for regime $\Delta Q_{sc}=0.03$, $\xi=0.01-0.02$ (this is regime of interest for eRHIC).

For small ΔQ_{sc} (~ 0.03), eRHIC:
Can we find better working point?

Already did similar study with Au ions,
in the regime of very weak beam-beam.

resonances to 15th order



APEX, April 4, 2012

study # 3
(April 2012)

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First, attempted to set-up working point just below integer:

w.p. $(Q_x, y) = (0.98, 0.97)$

- Not easy to have well-controlled machine and be able to inject high-intensities. We gave up after some time.

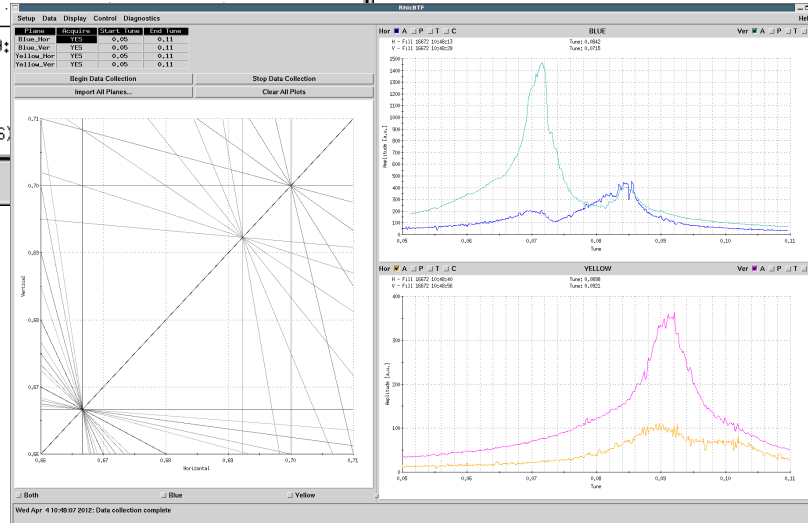
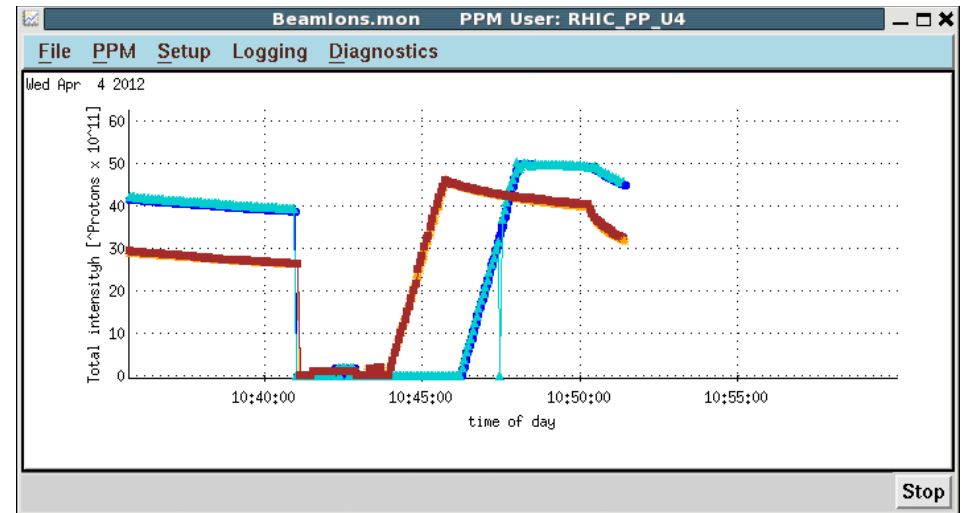
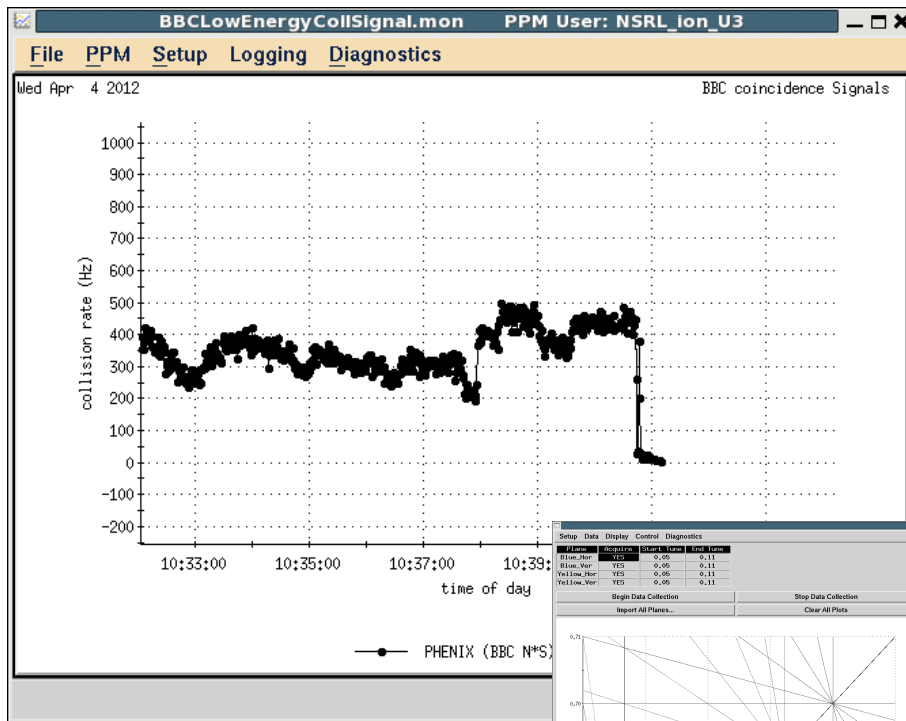
Decided to move above integer to

w.p. $(Q_x, y) = (0.08, 0.07)$

- well behaved machine
- experiment worked nicely

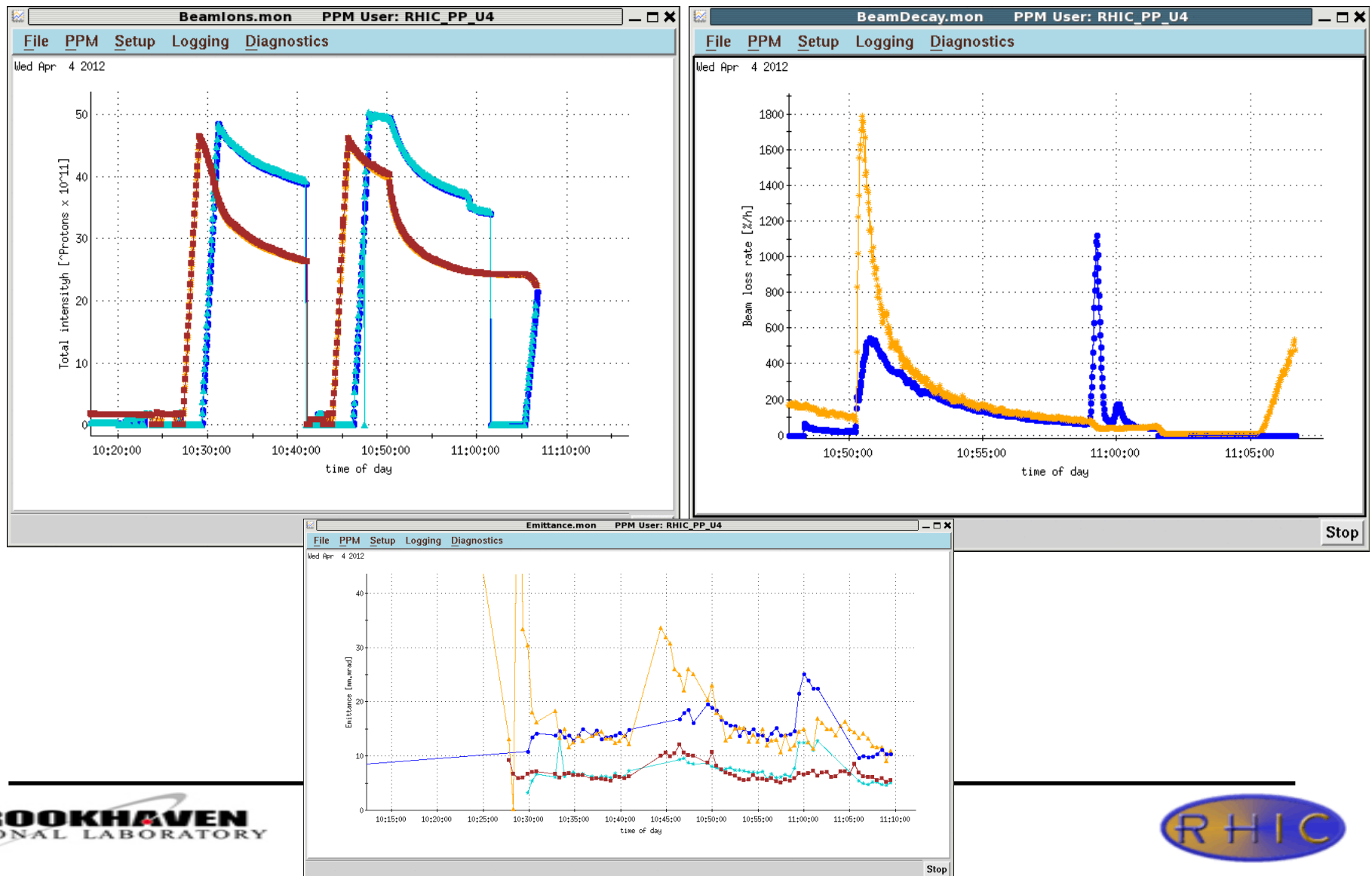
Result: not as good as has hoped, and as observed for similar working point but in the regime with weak beam-beam (APEX with Au ions at new integer w.p.).

April 4, 2012: effect of collisions



April 4, 2012: effect of collisions

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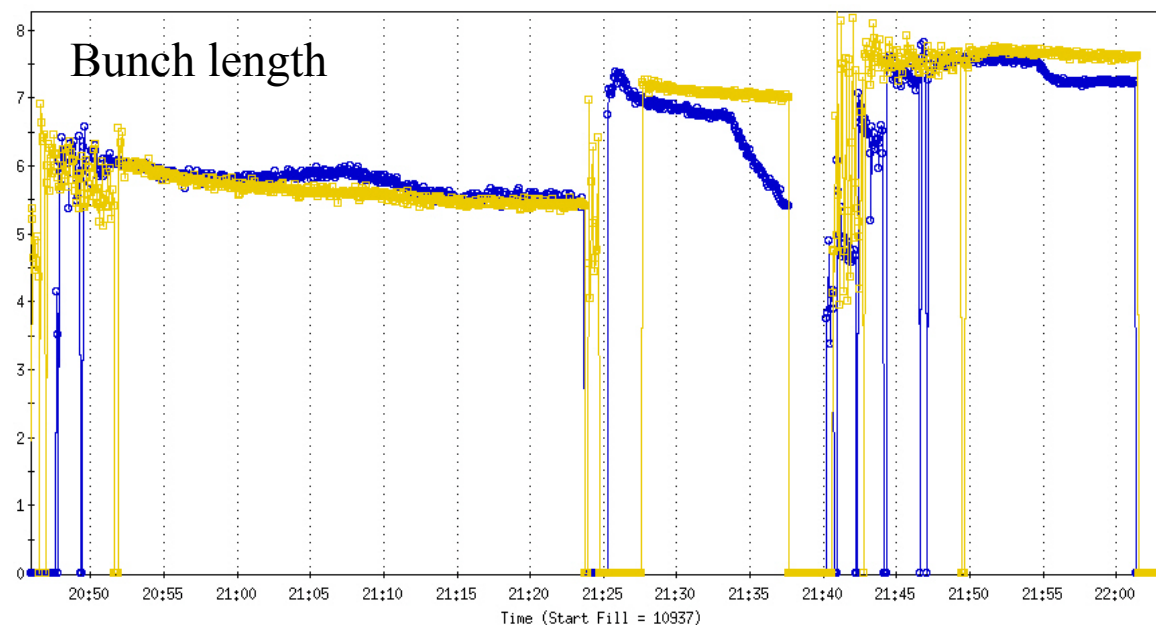
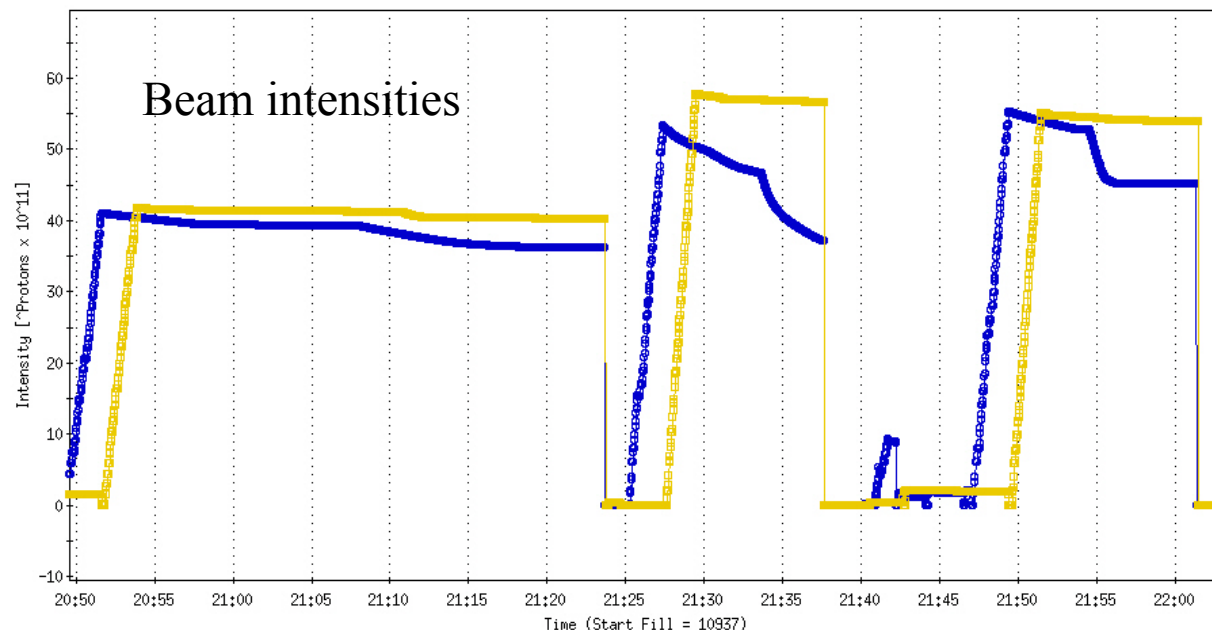
Protons @ $\gamma=25$

$$\Delta p/p = 1.5 \cdot 10^{-3}$$

Losses are seen in the
longitudinal plane

In eRHIC:

$$\Delta p/p = 3 \cdot 10^{-4}$$

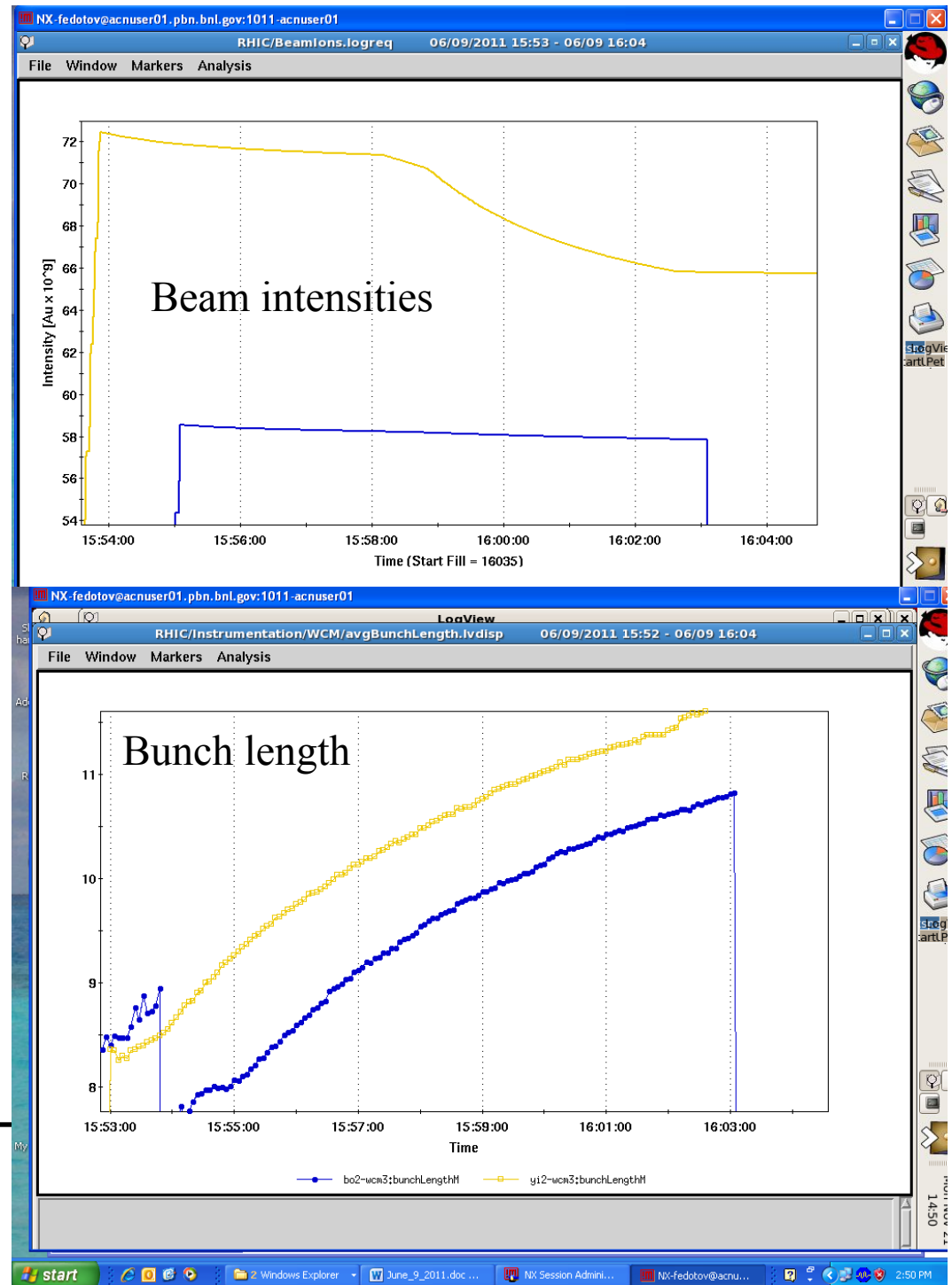


bo2-wcm3;bunchLengthM:valueAndTime yi2-wcm3;bunchLengthM:valueAndTime

Au ions
@ $\gamma=10$

$$\Delta p/p = 5 \cdot 10^{-4}$$

No obvious losses are seen in the longitudinal plane



Run-13

Remaining question:

-What would be the beam lifetime with the momentum spread more similar to the eRHIC value?

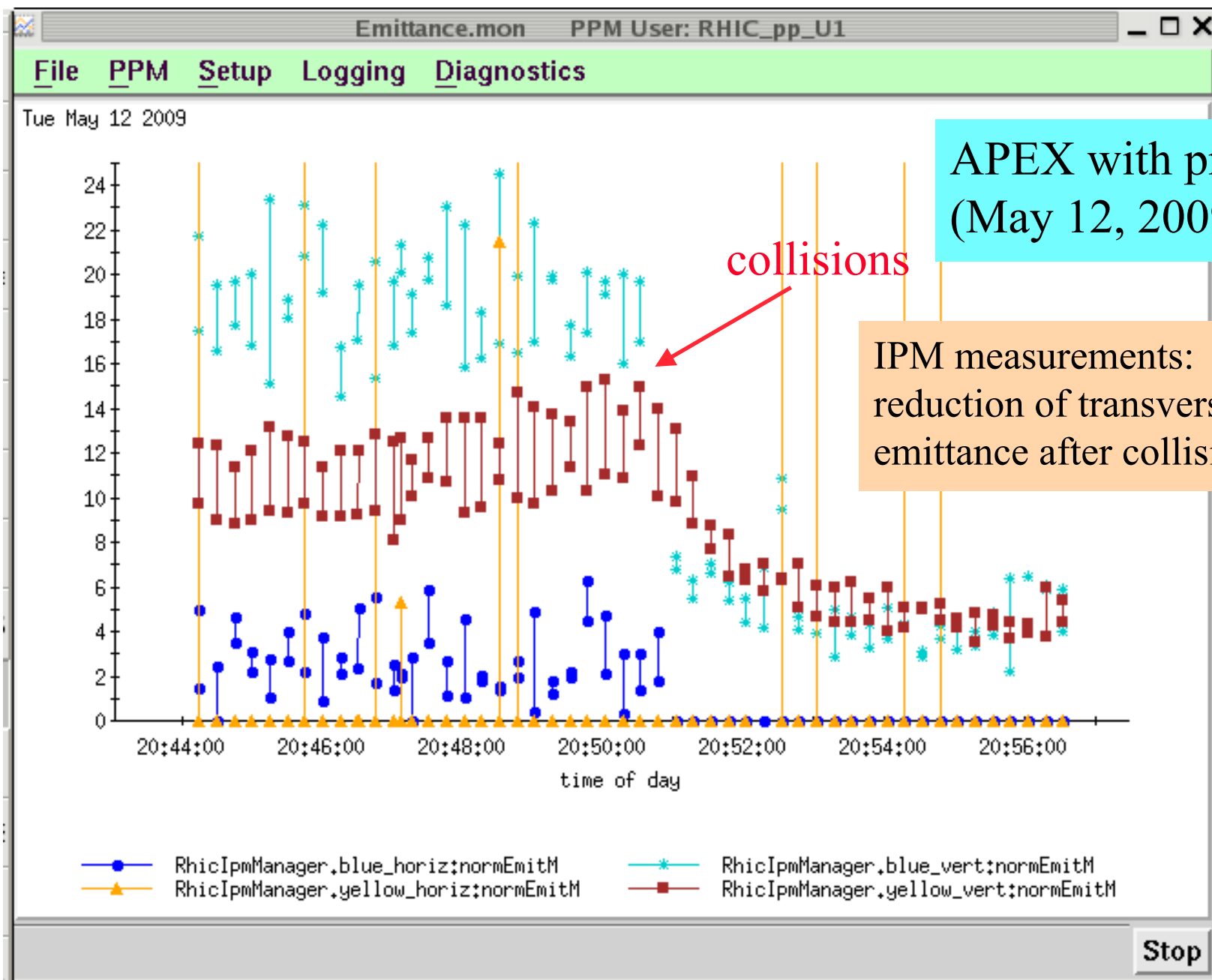
Suggested measurements with protons:

-Compare the beam lifetime obtained at different momentum spread (9 MHz versus 28 MHz RF system) but at the same space charge and beam-beam parameters.

-Do the measurement at (0.69,0.68) working point area; compare the beam lifetimes with exchanged Blue and Yellow working points.

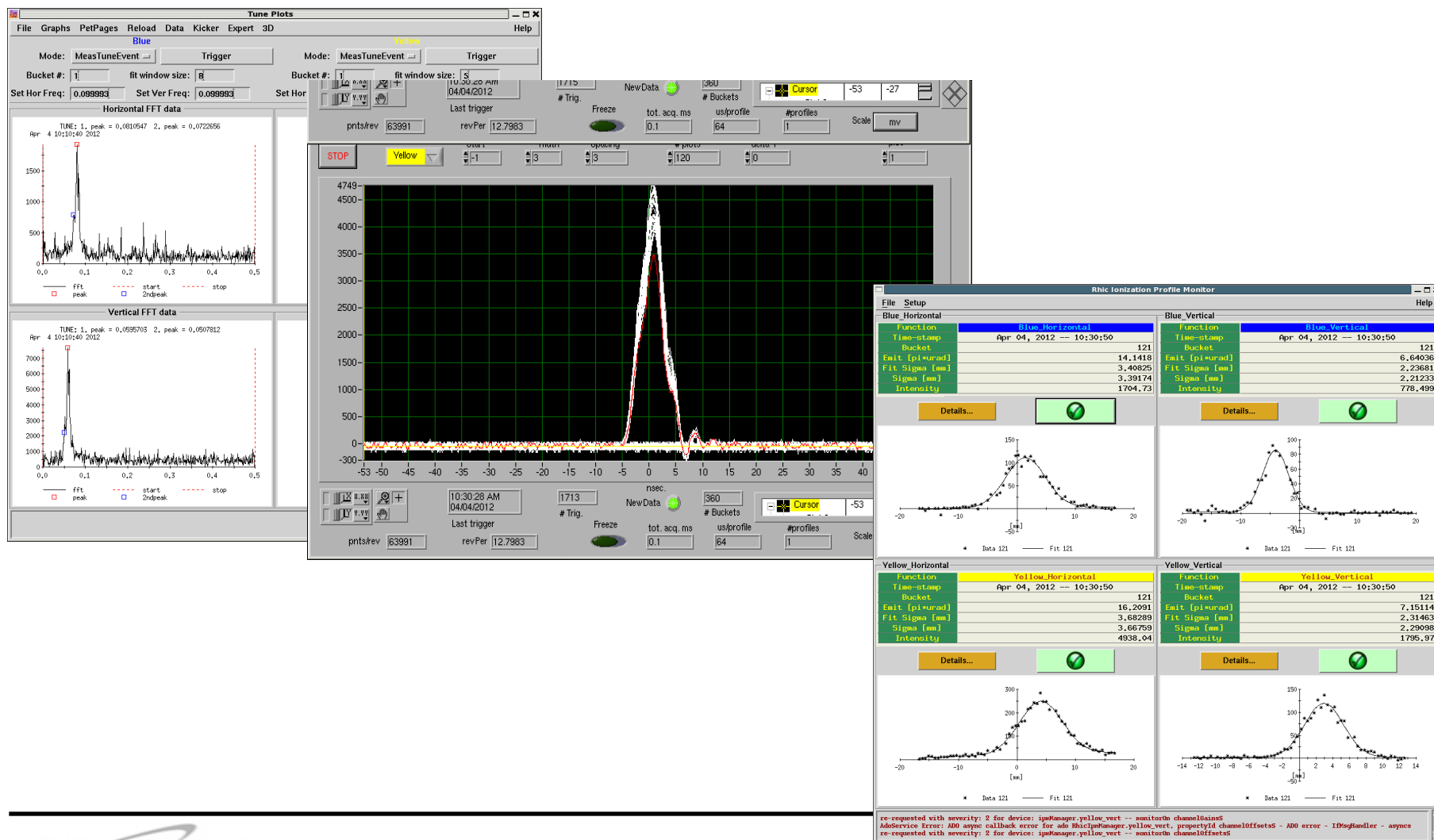
-Take advantage of machine tuning done during the Integer working point studies and do the measurement at that working point area.

Backup Slides



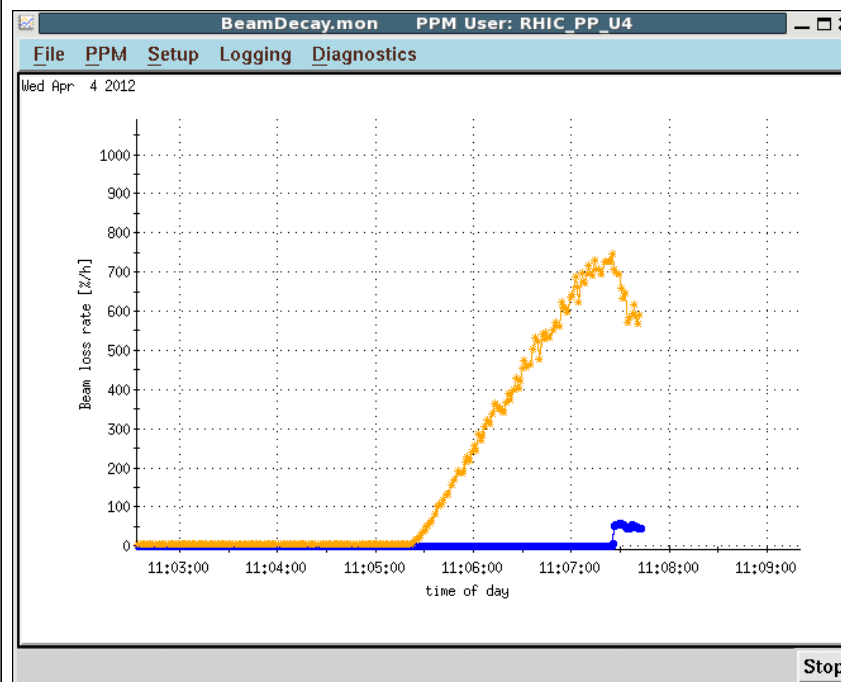
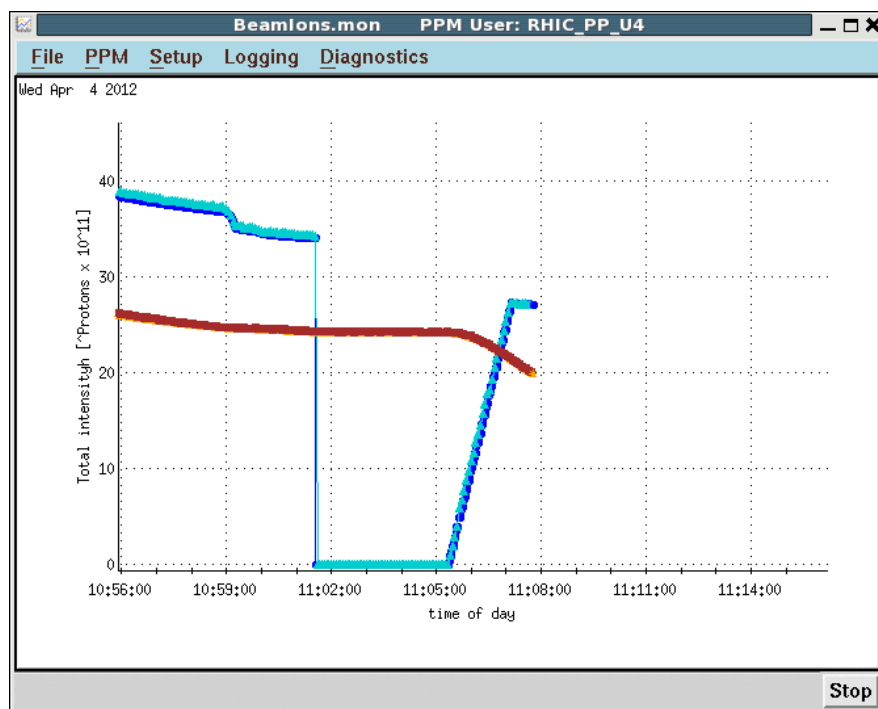
April 4: Protons at injection w.p.=(0.08,0.07)

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Reduced intensity:

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Injecting directly in collisions:

- lower intensity beam was kept in Yellow while fresh low intensity beam injected in Blue